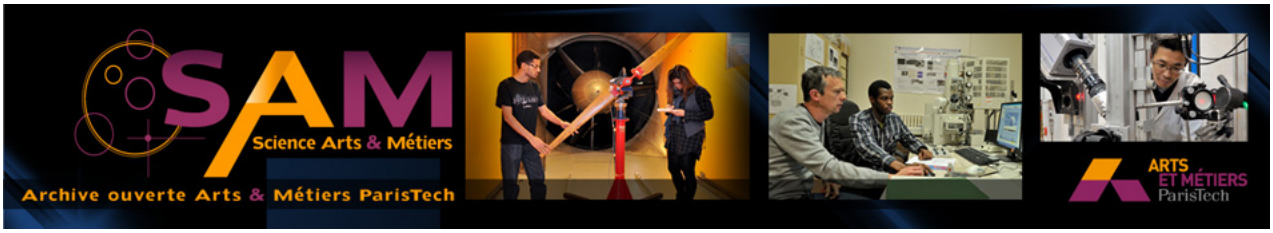

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A user oriented framework to support environmental performance indicators selection

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Abstract

Ecodesign is an approach to reduce environmental impacts of products. This approach is based on the assessment and the improvement of environmental performance. In order to justify ecodesign choices, indicators must be used to follow environmental performance and to insure their potential benefits. There already exist environmental performance indicators selection methods, and almost all the methods highlight the fact that the needs of users are important, but no one explicitly express which are the users, what are their needs and what are the type of indicators that can be applied in ecodesign approach. This paper focuses on the users' needs and proposes a combined framework for environmental performance indicators selection.

1. Introduction

Ecodesign is a product development approach based on the assessment of environmental impacts of a product throughout its whole life cycle (from raw material extraction to end of life treatment, including usage and transportation) and then the implementation of improvement strategies to reduce environmental impacts. This approach involves the participation of all the services of the company and all the actors of the value chain. The framework of this method is defined by the standard ISO 14062 [1]. Most of the time the environmental impact assessment is based on environmental indicators as climate change, ozone depletion, ecotoxicity, eutrophication, etc. Their monitoring allows to justify ecodesign choices and to ensure their potential benefits. Furthermore, it prevents the pollution transfer or at least it allows arbitrating them. One of the most useful methods to evaluate the environmental indicators is the Life Cycle Assessment (LCA), a standardized method by ISO 14040 [2] and ISO 14044 [3] standards. But LCA is an expert method [4] and the several environmental indicators used can be difficult to understand and interpret by company members as decision makers, designers, buyers, etc. and also external stakeholders as investor, suppliers, and customers, etc. To address this issue, Environmental Performance Indicators (EPI) became more and more present at company level [5]. These indicators provide information about an organization's environmental performance [6]. EPI give information to measure environmental impacts at "t" time and the influence (positive or negative) of actions. Their major function is to give simplified information, but their meaning is often more important than what can be observed [7]. EPI are easier to follow and to improve by corporate actors. They are also easier to communicate to stakeholders.There are different kinds of EPI. The three main are: i) management performance indicators as percent of employees trained to environmental aspects, ii) operational performance indicators as quantity of recyclable material per unit produced, and iii) environmental condition indicators as concentration of specific contaminant in ambient air [6]. In the case of ecodesign approach, the operational performance indicators are the most interesting EPI, even if the two other categories can be used. Currently, a wide variety of EPI can be used, for example Issa & al. [8] refers more than 261 EPI in the field of ecodesign.

The proper selection of EPI is quoted as a success factor for the development of ecodesign in companies [8], [9]. EPI

help identify targets and then make improvement in relation to environmental objectives.

Several methods and frameworks have been defined to select EPI [7-8, 10-19]. Most of the time, these methods are based on environmental improvement objectives, the context of the product and its environment. The context includes the applicable regulations, the sector issues, the business strategy, the environmental aspects of the product, the geographical and temporal scale of analysis and so on. The most of EPI selection methods, for ecodesign or environmental management, highlight that user needs must be taken into account to define a set of EPI. Nevertheless, in any of the methods the users, their needs, the kind of indicators which can be used are not explicitly indicated. In these methods, a set of indicators is defined to answer to all environmental issues and to take into account all the different users' needs. It can lead to have a wide range of EPI, instead of only few as recommended by almost all the methods. In fact, the more there is EPI and more the decision process will be difficult to manage. The set of indicators must be as small as possible [20] and specific to each user [21]. Moreover, internal and external actors of the company have different communication needs which can be conflicting [22]. Some studies have tried to consider EPI function for each user but are not oriented product development and do not take into account all kinds of users [23]. In other field that environment, The International Atomic Energy Agency [24] also consider users' requirements, but the kind of users are not involved in ecodesign project.

The following section will present a review of some existing methods with their specifications. Section 3 describes the combined framework to take in consideration the context of the company and actor needs. Section 4 presents the discussion and conclusions.

2. Review of existing methods

There are already several methods to select EPI. The table 1 describes each of the most interesting methods, linked to the framework develop here, with their characteristics and their advantages and disadvantages. This table highlights if the method is product oriented for ecodesign approach and if the authors consider the user needs are important to take into consideration to select EPI.

None of these methods give information about the users' needs and the specific type of EPI which can be applied. Most of product oriented approaches do not mention this information. This paper tackles an existing gap in literature about indicators needs of ecodesign actors (internal and external). Literature is mainly focused on defining only one set of indicators for the company or a family product which must follow all the major environmental issues in first and then that must meet all users' needs if possible.

Table 1. Review of existing method

Selection method	Description	Product oriented approach	Consideration of the users' needs
Pressure-State-Response model or Driving force – State –Response model [7], [14], [19]	Use the causal chain of environmental impact to determine the performance indicators. Use the causal chain and propose to select from the identification of key nodes (root-nodes, central nodes and end of chain nodes) [14] + Take in consideration interrelation of indicators [14] - Do not take into account the sector and regulation pressure and it can be difficult to evaluate the causal chain. - Build the causal chain can be not easy.		**X**
Environmental improvement objectives [8] [10]	+Implement EPI in the product development process by collecting data and measuring EPI, checking the performance results and defines actions to improve product performance +Select EPI in function of the environmental improvement objectives. +Database of EPI classified by life cycle stage, the environmental aspect and type of measure [8]. +Choose specific indicators for the company, not contained in the database. -Define environmental priorities and objectives involve previous knowledge about the product and its context and prioritization of improvement objectives.	**X**	
Expert survey [11], [12], [13].	+Weight of indicators by experts from the environment, product sector and others from a preselection in order to select the most important indicators - Potential influence of experts with their own a priori		**X**
Company survey [15].	Close to the expert survey, but here there is a first analysis of the company and there environmental goals then strategical actors are identified. After that a survey is subject to these actors in order to define most environmental strategies and then indicators set.		**X**
Product oriented environmental management system [16].	Select the EPI from three levels: sector (general indicators), company (based on the environmental policy of the company), and project/product (linked to ecodesign implementation).	**X**	
Balanced scorecard approach [17].	+Link the environmental performance with corporate strategic objectives. +Use a known method from another domain of the company - Not link to the product development.		
Stakeholder consideration [18].	Identify environmental impacts to define indicators. +Integrate stakeholders in the EPI selection and indicators must be useful to stakeholders internal and external.		**X**

+: advantages of the method; -: disadvantages of the method

3. Proposal of a combined method focus on actors

The framework is intended to support the identification of EPI to monitor environmental performance in the product development for all actors involved. The method proposed is based on three steps (fig. 1). The first step is the same as the methods based on environmental improvement objectives [8], [10]. The environmental issues of the product and its context need to be well known to define environmental improvement objectives. The second step defines actors (internal and external) and understands their needs and goals about the use of EPI. The last step selects one set of EPI for each actor and one set for the company.

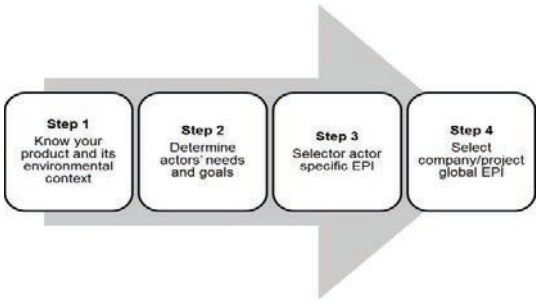

Fig. 1. Framework to select EPI

3.1. Step 1: know your product and its environmental context

The first step allows knowledge about environmental issues and context of the product:

- knowledge about environmental issues of the product along its all life cycle from raw material extraction to end of life treatment by performing a LCA or other environmental analyses. The LCA standard method [2], [3], is strongly recommended because it is one of the most complete method to do a life cycle analysis. As mentioned previously it is an expert tool. So, any specific environmental tools for the sector, others simplified tools or combination of tools can be used. Here the purpose of this step is to have an analysis which can identify all the environmental issues from all the life cycle and environmental aspect. This point will help to define environmental improvement objectives and focus the choice of EPI on issues which really matter.
- knowledge about regulation, sector and geographical and temporal impacts consideration. This step will allow the company to well know the environmental context of the company and its products and to prioritize environmental goals improvement. This phase will also help companies to ensure not to have omitted major environmental problems of the sector in the previous analysis.

For example, if LCA results highlight that the major issue of the company is the energy use of the use phase of their product. Their eco-design goals will be to focus on the users' behaviours and the energy efficiency (involving suppliers, as suppliers are more and more integrated into their client's development process [25]). Another example, if the major issue is the use of toxic substances or material, their eco-design goals will be to focus on the manufacturing phase and the choice of components and materials. Then it will help to determine user indicators and goals. In the first example end of life channel actors are not important. In the second case, end of life channel actors must have EPI because there are directly linked to treatment of toxic substances or material.

This first step is inspired from the existing methods based on environmental improvement objectives [8]. This step is not easy and requires time, but it will be very useful to prioritize environmental improvement objectives and determine indicators set for each user. These objectives must be defined in function of major environmental aspects and life cycle phase of products. The monitoring of EPI linked to this analyse will help to avoid pollution transfers.

3.2. Step 2: Determine actors' needs and goals

The second step determines which actors will used EPI and in which goals. Firstly, actors must be identified. The actors can be internal and external actors to the company. Table 2 lists the different actors that can be involved in the implementation of ecodesign.

Then, the needs of each actor must be defined. The usual tools of need analysis can be used (surveys, SWOT matrix…). The internal actors will use EPI to follow environmental improvements in the development product and to select design alternatives. They will also use EPI to follow the global performance of the company and to communicate the environmental performances to external actors. The external actors will use EPI to get environmental information on the product to make informed choice for example and to improve environmental performance by themselves. Table 2 summarizes some examples of needs of each actor. This table is not comprehensive.

3.3. Step 3: Select actor specific EPI

The results of this step are a set of indicators for each actor which response to the needs and goals defined below. Several criteria must be taken into account when selecting EPI, including the criteria of the standard ISO 14031 [6]: relevance, completeness, consistency, accuracy and transparency. The EPI must be used and useful for the user, scientifically founded, and show the reality of the trend of the EPI. Indicators should be independent from each other.

- Specific actors involved in the product development process or in the product life cycle will have technological indicators which are more quantitative. EPI must be technically linked to the product specification as the weight, the material composition, the energy consumption, the recyclability rate, etc. Indicators for other actors more

Table 2. Actors needs and type of EPI for Ecodesign approach

	Actors	Examples of needs	Type of EPI
Internal to the company	Decision maker**	Follow environmental performance of the company compared to environmental objectives [23] Have information to make decisions on environmental strategy Communicate environmental performance to stakeholder [23] Give feedback information to inform and motivate the workforce [23] Give environmental performance objectives to the workforce	kg CO_2 per year due to the company activities kg of CO_2 saving by year due to workforce contribution kg of waste generated by year due to company activities Number of new product with an ecodesign approach
	R&D service*	Follow innovations potential environmental benefices	Global environmental footprint of product Energy efficiency of the product Lifespan of the product
	Designer/ engineer*	Follow environmental performance of the product during all the life cycle Identify ecodesign strategy	kg of problematic material relative to the total weight Lifespan of the product Weight of packaging relative to the total weight
	EH&S / environment *	Follow air, water, soil pollution Follow life cycle assessment results	Climate change Ozone depletion Acidification Degree of compliance with environmental regulation
	Marketing**	Identify new market opportunity [23] Defend a position on market [23]	% of competitor with environmental claims Footprint of product Environmental regulation compliance
	Buyers*	Exchange information with suppliers Give information to environmental performance from suppliers	Number of suppliers with environmental requirements Number of suppliers with eco-design approach kg of problematic material relative to the total weight of the component
	Quality*	Follow company environmental requirements to suppliers	kg of hazardous substance release in environment Number of products returned because of breakdown Number of suppliers with environmental management system % of suppliers with non-conformity
	After sale*	Follow environmental customers' requirements	Number of customers with environmental requirements Number of customers with requirements of information of sustainable behaviours Number of customers trained to sustainable behaviours
	Production*	Follow environmental performance linked to the production	kg of waste generated Energy consumption by product manufacturing kg of dangerous substances leakage kg of air pollutant per product
External to the company	Suppliers*	Exchange information with companies to improve components environmental impacts [23] Gives information about environmental performance of their product	Energy consumed per components manufactured % of problematic material relative to the total weight of the component CO_2 equivalent per components manufactured
	Customers/ end-user*	Information about environmental performance of the product [23] Follow their own environmental performance during usage Help to choose between different products	Energy consumption specific to the end user Energy labelling CO_2 or energy saving by applied sustainable behaviour during a period Noise
	End of life channel actors*	Information about end of life treatment Give return information to the company	Disassembling time % of recyclability Non-compatible materials for recycling kg of hazardous substances in the product
	Investors, state**…	Have information about environmental performance Ensure environmental regulatory compliance [23] Indicator of financial performance [23] May indicate environmental liabilities that could affect a firm's financial performance [23] Develop database useful in developing and implementing a government's environmental policy [23]	Degree of compliance with environmental regulation CO_2 footprint of the activity by year Water footprint of the activity by year

* involved in the product development process or product life cycle (specific indicators)
** involved in management (macroscopic indicators)

involved in the management of the company and projects will be more qualitative and link to the global performance at different company' scale, sector, regulation, etc.

- For leader/decision maker and external stakeholder as investor/state, EPI will be more macroscopic indicators and show the global performance of the company. EPI are not specific to a product or a technological solution.
- For R&D service, indicators should not be related to a technological solution. EPI must be linked to a given function in order to show the potential environmental benefice of innovations.
- For designer/engineer, EPI must be directly linked to a technological solution. They must take into account all the life cycle phases of the product.
- For EH&S/environment service/LCA expert, EPI must be linked to air, water, soil pollution and environmental impacts than can be local or global as used in LCA for example.
- For marketing, EPI must show the advantages compared to competitors.
- For buyers, EPI must be linked to suppliers and their environmental performance.
- For quality service, EPI must be linked to the technical performance of the product and the respect of environmental requirements to suppliers.
- For after sale service, EPI must be linked to the use of the product.
- For production, EPI must be directly linked to the environmental performance of the production plant (product or service manufacturing operations) but not others company facilities.
- For suppliers, EPI must give information about environmental performance. They are linked to technological aspect and management aspect.
- For Customers/end-users, EPI must mainly be linked to their own usage and the influence than they can have by their choice.
- For end of life channel actors, must be linked to material used and end-of-life treatment.

Table 2 summarizes some examples of EPI that can be used by each actor depending on their own needs. As mentioned previously there is a lot of EPI. The table is not comprehensive. Other examples can be found in other scientific literatures as [8], [26], and [27]. The numbers of EPI chosen for each actor will depend on the case, but a lot of indicators can be difficult to manage. The set of indicator has to be as small as possible, in agreement with [20]. It is also important to consider a general set of indicator for the company and for each family of product to communicate environmental performance in a suitable way, as existing methods. The general set will be defined to respond to context issues (mainly regulation, sector and customers' expectations) and also major environmental issues from the environmental analyze in the first step.

For a same ecodesign objective, for example, reduce energy consumption in usage phase, each actors involved will have different indicators. It can be the real annual energy consumption for end-users; the coefficient of performance for designers, the fossil resource depletion indicator for the LCA expert, etc.

3.4. Step 4: Select company/project global EPI

Even if each actor should have a specific set of indicators, these sets of EPI should be correlated in order to choose the best sustainable solution in the product development, and to communicate global information. To do that, each actor must share the context and framework of their needs and find the best solution through win-win compromise.

The result is the creation of two sets of global indicators for the company or for a project: i) one set linked to the product development helpful to compare alternative design solution or to follow potential improvements; ii) one set specifically for the environmental management of the company and the external communication. As mentioned previously, internal and external needs can be conflicted and need two sets of indicators [22].

- For the set of indicators linked to the product development, the different needs of each actor should be taken into consideration, also as global environmental product issues. Links should be found between the information given by each specific actor indicators. For example: the number of product return because of a breakdown can be an indicator of quality service, R&D service can have an indicator linked to the reliability of the technology. The lifetime of a component can be an indicator of designer/engineer. These IPE can lead to a global indicator which can be the lifespan of the product.
- For the set of indicators linked to the management/communication, it must give information on the environmental strategy of the company (example, the number of Eco-designed products) and key performance indicators to ensure external users' needs (example, yearly CO2 emissions due to the company activities).

4. Discussion & conclusion

The existing selection method can be useful, but generally just mentioned to take the indicator user needs, but do not give detailed information and help to specify this needs and the type of indicators which can be used. It is recognized that the good selection of EPI and their adaptability to different users is essential for a performing eco-design strategy implementation. The main contribution of this work is to take in consideration the needs of the different user indicators. This paper presented a new combined framework for environmental performance indicator selection based on existing EPI selection methods and specific to each user. It is in opposition of existing methods which consist to determine a set of indicator. Our method takes into consideration all users' needs. Here, each kind of users should have a personal indicator set in order to manage and improve environmental performance. For several actors, EPI can be identical or dependent. A tool must be built to allow the communication of information between company services and to calculate and

link EPI of all actors. The tool may be also useful to calculate global indicators from individual indicators data by using mathematical routines.

Moreover, it can be difficult for the different actors dealing with this system (designers, buyers, users) to manage a lot of indicators, especially when they have to make a choice between several solutions. Each has his own objectives, and indicators detail level needs. This it is not the same trend on all the indicators. In order to manage this aspect, in further work, a multi-criteria management approach should be used to improve global environmental performance of products. The multi-criteria analysis should be easy to apply. In addition, the adaptation (limitation) of indicators, depending to the point of view, will be defined in order to design an efficient score card.

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